



Climate-Hydrology Forecasts and Risk-Based Reservoir Management in Northern California:

Design and Initial Tests of the Real-Time INFORM System

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WHAT IS THE INFORM SYSTEM?

- A REAL-TIME HYDROLOGIC FORECAST DECISION SUPPORT SYSTEM
- FIVE LARGEST CALIFORNIA RESERVOIRS and DOWNSTREAM.
- TIME SCALES HOURS-TO-SEASONS.
- UNCERTAINTY EXPLICITLY TREATED IN ALL COMPONENTS.
- DECISION SUPPORT FOR SUPPLY, FLOOD CONTROL, HYDRO-POWER, FLOW, PLANNING.
- <u>MULTI-AGENCY</u> SUPPORT AND USE.







THE INFORM SYSTEM

PRECIPITATION AND TEMPERATURE FORECASTS

RAIN-SNOW-SNOWMELT - DOWNSCALING MODELS

RIVERS - HYDROLOGIC MODELS

RESERVOIRS

DECISION SUPPORT
RELEASES and
DOWNSTREAM SYSTEM







PURPOSE OF INFORM

INCREASE EFFICIENCY OF WATER USE

USING CLIMATE, HYDROLOGIC AND DECISION SCIENCE





SPONSORS-COLLABORATORS

Sponsors:

CALFED Bay Delta Authority
California Energy Commission
National Oceanic and Atmospheric Administration

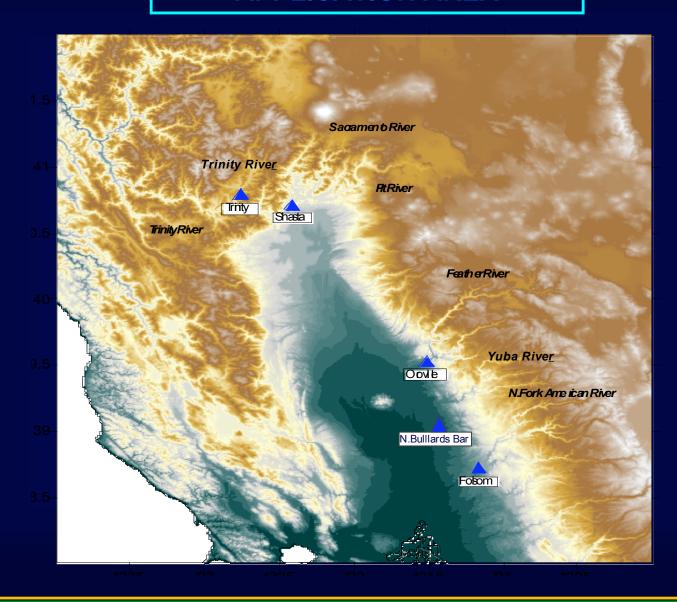
Collaborators:

California Department of Water Resources
California-Nevada River Forecast Center
Sacramento Area Flood Control Agency
U.S. Army Corps of Engineers
U.S. Bureau of Reclamation





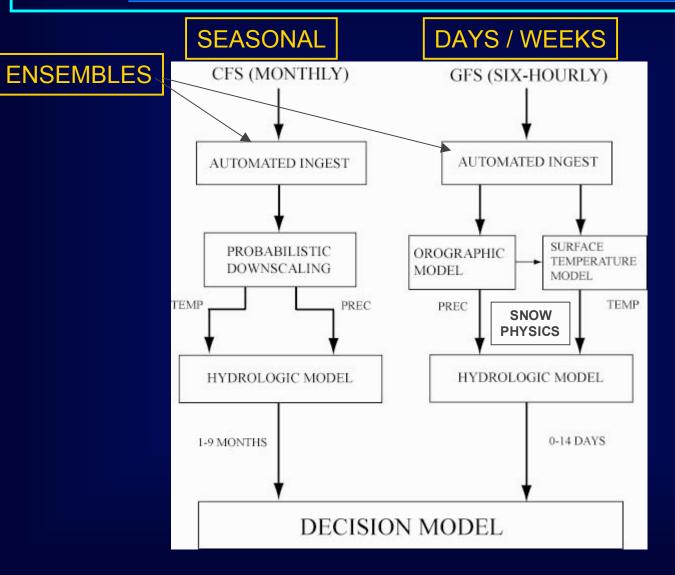
APPLICATION AREA







MET. / CLIMATE / HYDRO. SYSTEM DESIGN







First Three Years of INFORM Complete

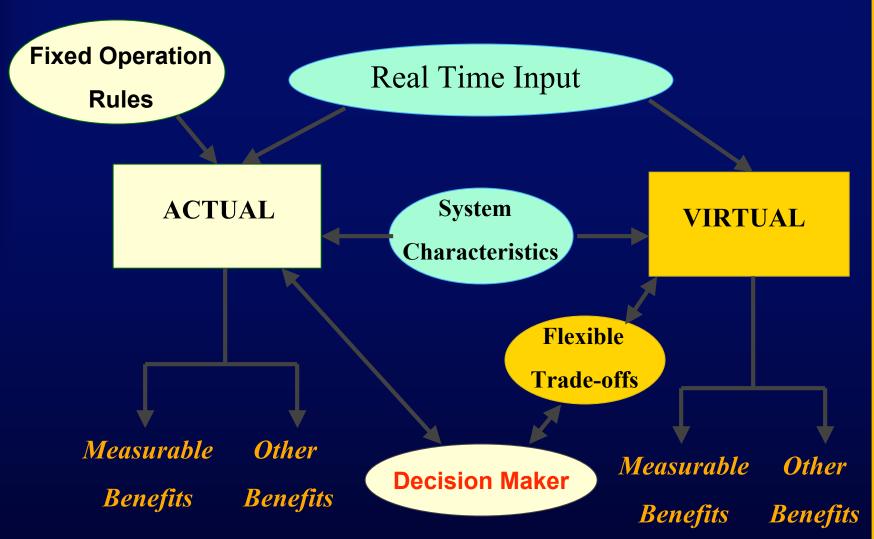
- INFORM system developed and components tested with historical data.
- Initial demonstration with real time data from 2005-06 wet season in California.







<u>Demonstration Concept – Testing and Verification</u>





WET SEASON 2005-2006 ASSESSMENTS

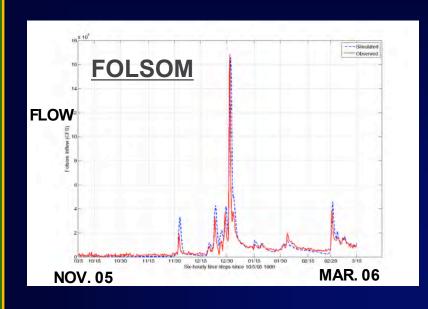
Simulations with:

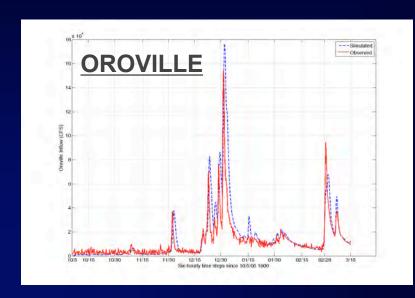
- Observed Precipitation and Temperature
- Precipitation forecasts
- Temperature forecasts (critical for snowmelt)
- Inflow forecasts









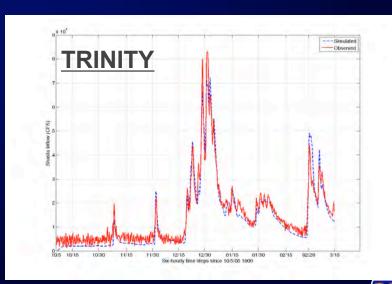


HYDROLOGICAL MODELS

WORK WELL

OBSERVED PRECIP. & TEMP.

SIM OBS





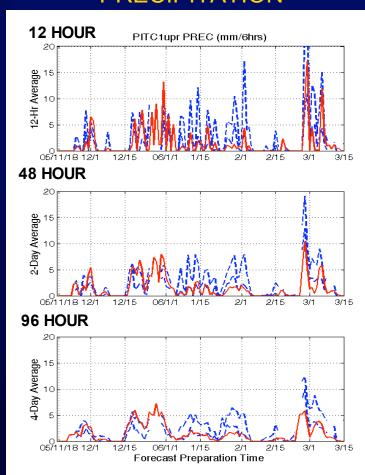
ENSEMBLE FORECAST VALIDATION

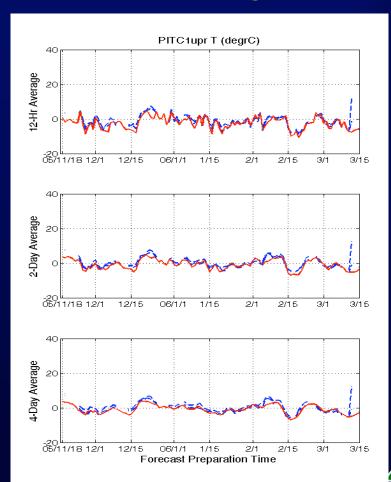
SIM. (ENSEMBLE RANGE)
OBS

PITT RIVER

PRECIPITATION

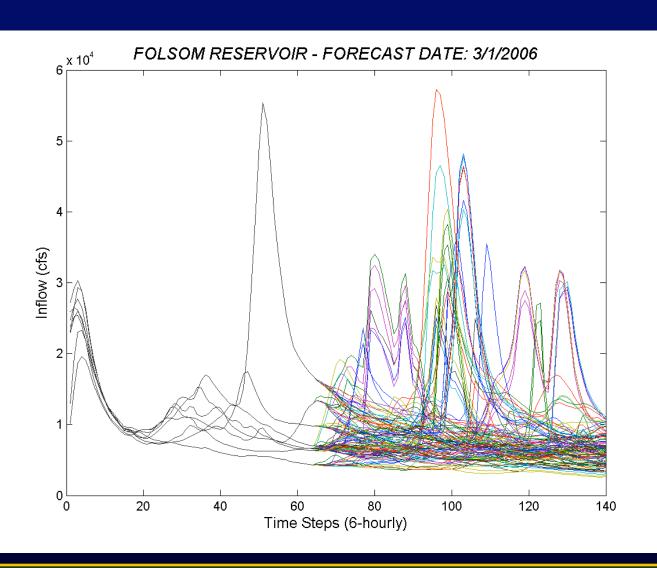
TEMPERATURE







Blending of Synoptic and Climate Time Scale Forecasts













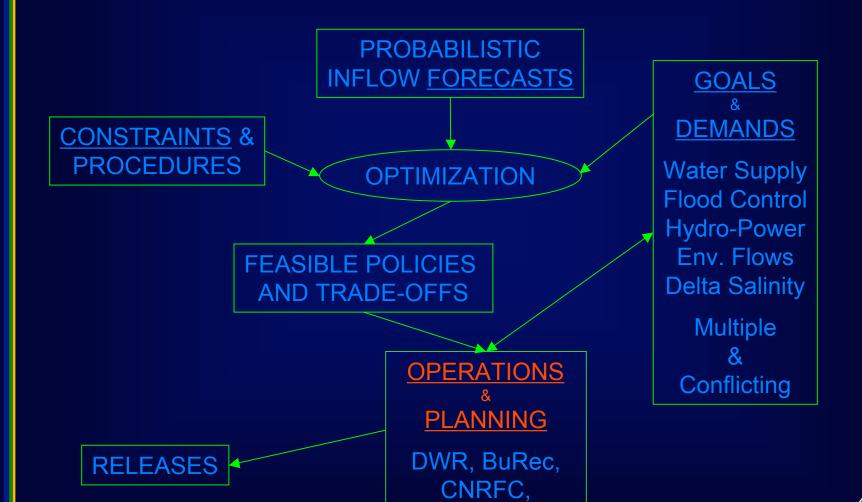
water supply – flood control - hydro-power – downstream flow











USACE



INFORM DSS: Overview Multiple Objectives, Time Scales, & Decision Makers

Actual Hydrologic Near Real Time Decision Support Conditions Water Distribution Flow Regulation Hourly / 1 Day and Management Actual Demands **Hydro Plant Operation** Benefit/Impact Functions **Emergency Response Daily Decisions** Water Supply · Releases/Energy Energy · Flood Damage Target Conditions Env.-Ecosystem · State Variables Climate-Hydrologic Operational Tradeoffs **Forecasts** Mid/Short Range Decision Support Flood Management Demand Forecasts Daily, 6-Hourly, or Hourly / 1 Month · Water Distribution Water Supply · Energy Generation · Power Load/Tariffs Benefit/Impact Functions Monthly Decisions Env.-Ecosystem Management · Flood Damage · Water Supply · Env.-Ecosystem Targets · Releases/Energy Energy Flood Damage Target Conditions Env.-Ecosystem · State Variables Climate-Hydrologic Planning Tradeoffs Long Range Decision Support **Forecasts** · Water Supply/Allocation Weekly, 10-Day or Monthly / 1-2 Years **Demand Forecasts** · Energy Generation Carry-over Storage · Water **Management Policy** Env.-Ecosystem Management . Food · Energy Infrastructure Develpmnt. · Env.-Ecosystem Water Sharing Compacts Sustainability Targets Inflow Scenarios **Development Tradeoffs** Scenario/Policy Assessment · Urban/Industrial Development/Demand Monthly / Several Decades · Agriculture Scenarios Power System · Water/Energy Socio-economic & Ecological · Water/Benefit Sharing Sustainability · Environmental Sustainability



DOWNSTREAM PORTION

Central Valley Operations – State Water Project

- <u>SIMULATION OF DETAIL</u> IS MANDATORY
- MUST BE CONSISTENT WITH OTHER OPERATIONAL TOOLS
- COMPARE WITH CALSIM DWR / BuRec SWP–CVP Simulation Model
- EXCELLENT AGREEMENT
- EACH SYSTEM HAS PARTICULAR ADVANTAGES CALSIM CAN DISAGGREGATE INFORM LONG-RANGE POLICIES



INFORM-CALCIM Model Comparison Georgia Institute of Technology Is INFORM DSS Consistent with CALSIM? CALSIM INFORM Sacramento San Joaquin River Delta Storage Sequence - Shasta 5,000.00 4,500.00 4,000.00 2,500.00 2,000.00 CALSIM 1.500.00 1.000.00 500.00



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Spring 2006 Case Study



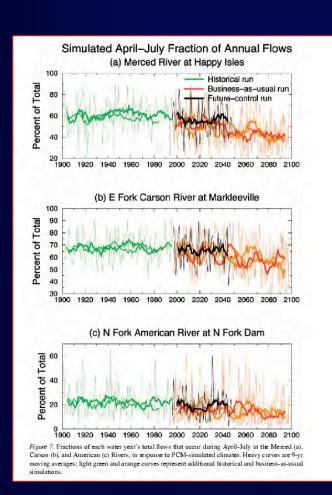
RESULTS

- · Forecasts correctly anticipated wet season;
- Planning model indicated that water allocation could be increased by 10% of base demand without compromising other water uses;
- INFORM DSS can generate a suite of other tradeoffs of potential interest to the management authorities;
- The system is ready to be applied operationally and evaluated with actual hydrologic forecasts and demand data by the stakeholder agencies over the next 2-3 seasons.





ADAPTATION TO FUTURE HYDROLOGICAL CLIMATE





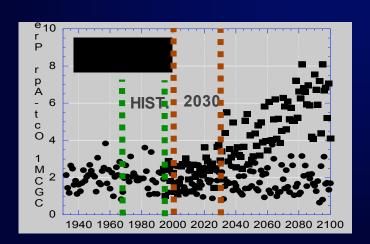
From Dettinger et al. 2004

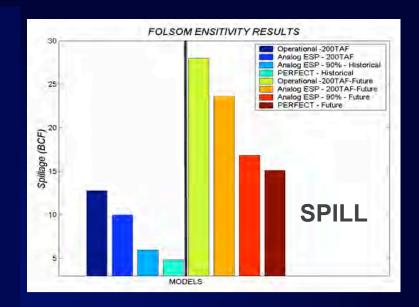


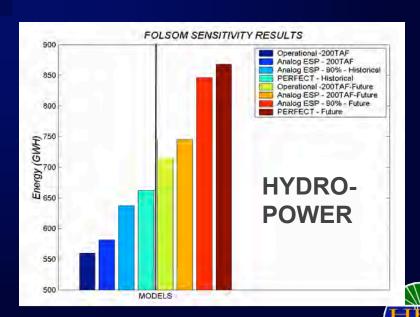


INFORM CLIMATE CHANGE EXPERIMENTS FOLSOM RESERVOIR:

- 1964-1993 HISTORICAL
- 2001-2030 CGCM1 (1% yr⁻¹)
- ANALOG FLOW TRACES
- NO CHANGES IN SWE
- NO CHANGES RUNOFF TIMING
- A) GOOD FORECASTS HELP
- B) KNOWN UNCERTAINTY IS ESSENTIAL.
- C) BEST EFFICIENCY IS ACHIEVED BY CHANGING PROCEDURES WITH A and B.





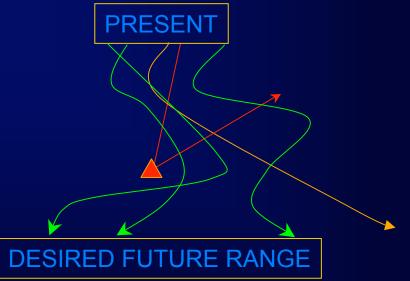




INFORM COMPONENTS SIMULATION, PLANNING, MITIGATION AND ADAPTATION

- OUTLINE FEASIBLE WATER USE FUTURES
- DEFINE FEASIBLE AND NON-FEASIBLE PATHS
- IDENTIFY / AVOID CRISIS POINTS
- TEST ADAPTATION AND MITIGATION STRATAGIES
- WHAT-IF SCENARIOS









SUMMARY

- 1) INFORM: A HYDROLOGICAL FORECAST DECISION SUPPORT SYSTEM.
- 2) UNCERTAINTY INCLUDED THROUGHOUT.
- 3) 5 LARGEST N. CALIF. RESERVIORS DOWNSTREAM TO BAY DELTA.
- 4) INCORPORATES MANY KEY DETAILS FOR CVO PLANNING.
- 5) FIRST OPERATIONAL TESTS DURING WINTER 2005-2006.
- 6) FURTHER REFINEMENTS, AGENCY TRIALS TO CONTINUE.
- 7) COMPLETE TOOL FOR CLIMATE CHANGE PLANNING.

